8. What is the material used for hydraulic tubing that is subjected to intense heat?

_____

9. What type of line is used to connect moving parts?

_____

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INSTRUCTIONS

1. You are about to start the programmed instruction Vapor Cycle Air-Conditioning System. You will be teaching yourself at your own speed. This is NOT a test, but a learning situation. There will always be an instructor available to answer any question you may have concerning the information being presented.

2. You will proceed from page to page, as in a conventional book. On each page, you will find one or more numbered sections. These sections are called "frames." You will go from frame to frame, using a piece of paper to cover upcoming frames. There is no advantage in peeking at new information. To be effective, you must follow the sequence. You must respond to each frame before you uncover the correct response. AFTER writing or selecting your response, be sure to check the left side of the next frame to see if your response was correct.

3. If your response was wrong, strike it out, reread the frame, and select another response. If your response was correct, continue with the next frame.

4. At the end of this program, there is a self-test to check what you have gained from the lesson.

5. Turn to page ii and read the objectives.

VAPOR CYCLE AIR-CONDITIONING SYSTEM

OBJECTIVES

The student will:

1. Select, from a list of statements, the statement that describes the principle of operation of a vapor cycle air-conditioning system. (Frame 1)

2. Select, from a given list, the type of liquid refrigerant used in most vapor cycle systems. (Frame 3)

3. Match a list of vapor cycle system components to their purposes. (Frame 5)

4. Complete a statement describing the driving device for the compressor and the evaporator fan in a vapor cycle system. (Frame 11)

5. Complete a statement describing the method of controlling the temperature in a vapor cycle system. (Frame 14)

6. Select, from a list of statements, the statement that indicates how the heat is removed from the space to be cooled. (Frame 16)

7. Complete a statement describing air induction through the condenser assembly during ground operation. (Frame 19)

SUGGESTED READING TIME 28 MINUTES

scientific fact that a liquid can be vaporized at any temperature by changing the pressure about it.

EXAMPLE: Water, at sea-level pressure of approximately 14.7 psi, will boil if the temperature is raised to 212°F. The same water, at a pressure of 90 psi, will not boil until the temperature is raised to 320°F. If this same water has the pressure reduced by a vacuum pump to 0.95 psi, it will boil at 100°F.

If the pressure about a liquid is increased, the liquid will boil, or vaporize, at a _____ (higher/lower) temperature.

higher

If the pressure about a liquid is reduced to below normal pressure by a vacuum pump, the liquid will boil, or vaporize, at a _____ (higher/lower) temperature.

_____ makes use of the scientific fact that a liquid can be vaporized at any _____ by changing the _____ about it.

temperature
pressure

2. Select the statement below that describes the principle of operation of a vapor cycle air-conditioning system. Circle the letter preceding your choice.

a. Vapor cycle systems utilize the compression of the refrigerant in the condenser to produce the refrigerated air.

b. Vapor cycle systems make use of the scientific fact that a liquid can be vaporized by changing the pressure about it.

c. Vapor cycle systems operate on the principle of thermal agitation of the molecules in the refrigerant.

b. is correct.

3. This same scientific fact applies to all liquids. However, liquids that boil, or vaporize, at low temperatures are most desirable

CONTINUE TO PAGE 3.

in most vapor cycle refrigeration units in aircraft as well as in home air conditioners and refrigerators. At sea-level pressure, liquid Freon 12 will boil at -22°F.

Liquids that boil, or vaporize, at _____ (high/low) temperatures are most desirable as refrigerants.

low

At sea-level pressure, liquid Freon 12 boils at minus ____ degrees Fahrenheit.

22

The refrigerant used in most vapor cycle air-conditioning systems is liquid _____ ____.

Freon 12

4. Select, from the following list, the type of refrigerant used in most vapor cycle air-conditioning systems. Circle the letter preceding your choice.

a. Freon 22.

b. Freon 12.

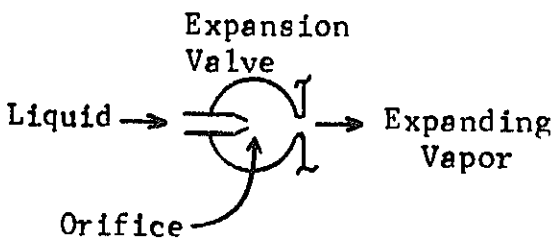
c. Carbon dioxide.

d. Liquid ammonia.

SCHEMATIC, PAGE 23, WITH THE FOLLOWIN

INFORMATION.

The liquid refrigerant is directed to an expansion valve that is mounted directly to the evaporator. The purpose of the expansion valve is to cause a rapid expansion of the refrigerant to a vapor by passing it through a small orifice (restriction).



A small orifice in the expansion valve changes the refrigerant from a _____ (liquid/vapor) to a _____ (liquid/vapor).

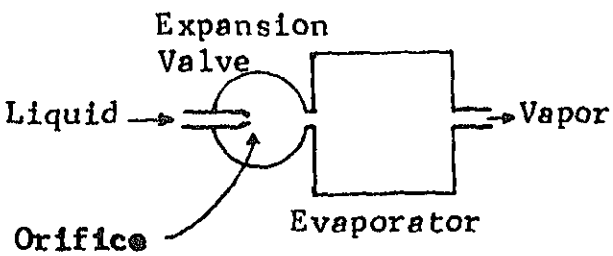
- -

liquid

vapor

The refrigerant enters the expansion valve as a _____ (liquid/vapor).

directly to the evaporator, and as the liquid Freon 12 changes to a vapor, the evaporator becomes the expansion chamber for this vapor. As the refrigerant changes to a vapor, it absorbs great amounts of heat surrounding the coils of the evaporator. The refrigerant leaves the evaporator as a superheated vapor.



Heat is absorbed from the surrounding area as the Freon 12 refrigerant _____ (condenses/vaporizes).

vaporizes

The refrigerant leaves the evaporator as a superheated _____ (liquid/vapor).

vapor

The expansion chamber for the refrigerant vapor is the _____ (condenser/evaporator).

expansion of the liquid in the _____

_____ (evaporator assembly/expansion valve).

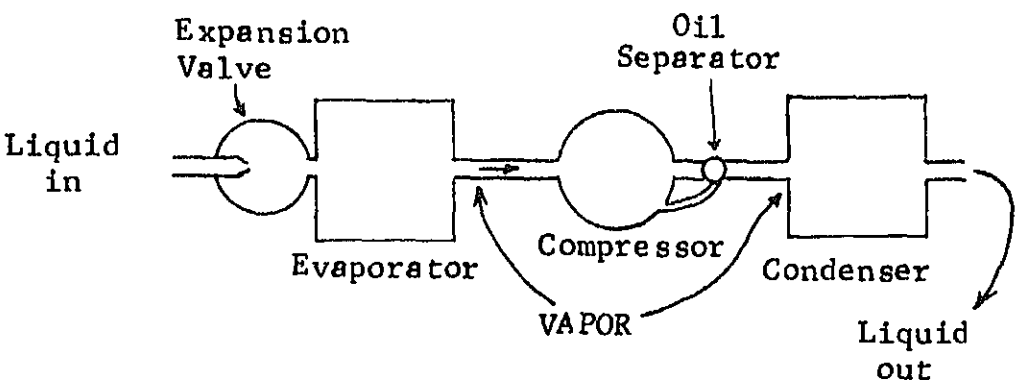
expansion valve

When the refrigerant vaporizes, it is capable of _____ (absorbing/dissipating) large amounts of _____ (coldness/heat) from the surrounding area.

absorbing heat

7. Reuse of the refrigerant vapor requires that it be condensed. To do so, the heat must be transferred to some substance, such as air or water. In aircraft vapor cycle systems, air is normally used. The refrigerant is changed back to a liquid by increasing the pressure with a compressor, while the heat is transferred to the air surrounding the condenser.

CONTINUE TO PAGE 7.



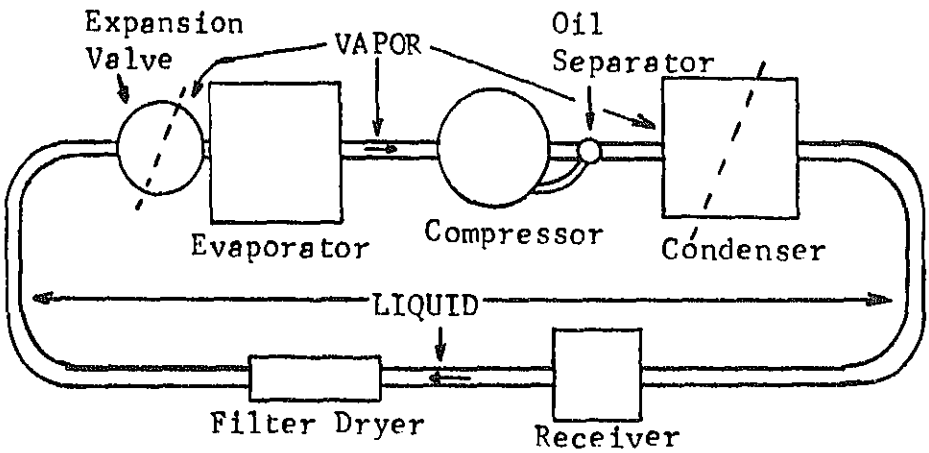
While the refrigerant vapor is being condensed, heat from the vapor is transferred to the _____ (air/water).

air	Reuse of the refrigerant requires that it be _____ (condensed/vaporized).
condensed	8. The heat within the space to be cooled is absorbed into the refrigerant vapor A compressor moves this heated vapor from the evaporator to the condenser. As the vapor condenses, the heat is transferred to the ambient air.

In the space to be cooled, the heat is removed by the refrigerant _____ (liquid/vapor).

vapor

9. Many components are necessary in a vapor cycle air-conditioning system for cooling and to allow reuse of the refrigerant.



REFER TO THE APPENDIX, PAGE 24--VAPOR CYCLE AIR-CONDITIONING SYSTEM COMPONENTS AND PURPOSES. REFER TO THE APPENDIX AND THE VAPOR CYCLE SYSTEM FLOW SCHEMATIC AND STUDY THESE COMPONENTS. AFTER SUFFICIENT STUDY, CONTINUE WITH THE FOLLOWING QUESTIONS.

The refrigerant is condensed in the _____.

- -

condenser

The expansion chamber for the refrigerant to vaporize and absorb heat is the _____.

	expansion of the refrigerant is the _____ _____.
expansion valve	The component that builds a differential pressure across the expansion valve is the _____.
compressor	Oil is separated from the refrigerant by the _____ _____.
oil separator	Surplus refrigerant is stored in the _____.
receiver	The liquid refrigerant is cleaned and water is removed by the action of the _____ _____.
filter dryer	Surges in the refrigerant flow rate are prevented by the _____.

receiver

10. Match the following list of components to their purposes. Write the letter preceding the component in the space provided before each purpose.

Component	Purpose
a. Receiver	____ Maintains the pressure differential required for operation of the expansion valve.
b. Evaporator	____ Separates the oil from the refrigerant and returns it to the compressor.
c. Compressor	____ Condenses the refrigerant to a liquid.
d. Expansion valve	____ Stores surplus refrigerant and prevents surges in the refrigerant flow rate.
e. Oil separator	____ Cleans and removes any water from the liquid refrigerant.
f. Filter dryer	____ Causes a rapid expansion of the refrigerant to a vapor.
g. Condenser	____ Acts as an expansion chamber for the refrigerant changing to a vapor to absorb the heat which surrounds the coils.

g.
a.
f.
d.
b.

compressor and the evaporator fan are each driven by a hydraulic motor. A hydraulic motor will develop more power than an electric motor of comparable size.

The compressor and evaporator fan are each driven by a(n) _____ (electric/hydraulic) motor.

---

hydraulic

For a comparable size of motor, more power can be developed with the _____ (electric/hydraulic) motor.

---

hydraulic

12. The speed of the hydraulic motor is controlled by an electrical signal from a pressure transducer in the low-pressure refrigerant line. Controlling the speed of the compressor d
the flow rate of the refrigerant t
therefore, the amount of vapori
evaporator.

CONTINUE TO PAGE 12.

flow rate of the refrigerant and, therefore, the amount

_____ (condensation/vaporization) in the evaporator.

vaporization

13. Complete the following statement b writing your answer in the spaces provided.

In the vapor cycle air-conditioning system, the compress and the evaporator fan are each driven by a(n)

_____ _____.

hydraulic motor

14. During the vaporization of the refrigerant, large amounts of heat are absorbed; hence, the cooling process takes place. Decreasing the speed of the compre results in less vaporization and reduced cooling. Incre ing the speed of the compressor results in more vaporiza and increased cooling.

CONTINUE TO PAGE 13.

increases, the amount of cooling _____ (increases/decreases).

increases

If the speed of the compressor increases, the amount of cooling increases because of _____ (more/less) vaporization in the evaporator.

more

The temperature of the cooled air in the vapor cycle system is controlled by the speed of the _____ (condenser/compressor).

compressor

15. Complete the following statement by circling the letter preceding your choice.

Temperature is controlled in the vapor cycle air-conditioni system by controlling the

a. speed of the evaporator fan.

b. engine bleed air.

c. high-speed turbine.

d. speed of the compressor motor.

the air surrounding the evaporator coils. A compress
carries this heated vapor to the condenser which is l
outside the space being air conditioned.

The heat is transferred by the refrigerant _____
(liquid/vapor).

vapor

17. In the condenser, the heat is transferred from the refrigeran
the outside air as the vapor is changed to a liquid.
makes the Freon 12 ready for reuse by the system.

The refrigerant vapor is changed back to a liquid and
heat removed in the _____ (compressor/conde

the statement that indicates how the heat is removed from the space to be air conditioned. Circle the letter preceding your choice.

a. The heat of the space to be air conditioned is reflected by the use of light colors and by utilizing the cool ambient air of high altitudes.

b. The heat of the space to be air conditioned is absorbed into the refrigerant vapor as it flows through the evaporator coils.

c. The heat of the space to be air conditioned is dissipated by forced air entering from an outside source.

b. is correct.

19. During ground operation, insufficient air will be flowing across the condenser to allow all the refrigerant vapor to condense. Therefore, air must be drawn (induced) across the condenser coils.

CONTINUE TO PAGE 16.

_____ (condense/heat), because there is insufficient air flowing across the _____ (condenser/evaporator).

condense
condenser

20. During ground operation, ejector nozzles are used to induce (draw) air across the condenser coils.

High-pressure air, from the engines, enters the ejector nozzles and creates a low-pressure area behind the condenser assembly, inducing air into the condenser scoop. This airflow cools the condenser assembly. (Refer to the vapor cycle system flow schematic.)

Airflow, to cool the condenser assembly during ground operation, is induced (drawn) into the scoop by the _____ (low/high)-pressure area created by the ejector nozzles.

ejector nozzles from the engine, is controlled by an ejector air shutoff valve. This valve is operated by an air/ground safety switch. When airborne, the valve is closed by the safety switch.

The ejector nozzles receive high-pressure engine bleed air only when the safety switch is in the _____ (air/ground) position.

ground

22. During ground operation, high-pressure engine bleed air flowing through the ejector nozzles creates a _____ (high/low)-pressure area behind the _____ (condenser/evaporator) assembly, inducing (drawing) air into the air scoop. Therefore, sufficient air will flow through the _____ (evaporator/condenser) assembly.

condenser

condenser

the vapor cycle air-conditioning system other than making required inspections and operational checks. Most system components are set at the factory, and because of the special equipment necessary, adjustments cannot ordinarily be made in the field. As an Aviation Electrician's Mate, you will be required to understand the system to be able to perform the required inspections and the operational checks.

NO RESPONSE REQUIRED.

YOU HAVE COMPLETED THIS PROGRAM. TURN TO PAGE ii AND READ THE OBJECTIVES AGAIN. IF YOU DO NOT FULLY UNDERSTAND ANY OBJECTIVE, REVIEW THE APPROPRIATE SECTION OF THE PROGRAM OR ASK THE INSTRUCTOR FOR CLARIFICATION. IF YOU UNDERSTAND ALL THE OBJECTIVES, CONTINUE TO THE SELF-TEST.

VAPOR CYCLE AIR-CONDITIONING SYSTEM

SELF-TEST

1. Select the statement below that describes the princip of operation of a vapor cycle air-conditioning syster Circle the letter preceding your choice.

   a. Vapor cycle systems operate on the principle of thermal agitation of the molecules in the refrigerant.

   b. Vapor cycle systems utilize the compression of th refrigerant in the condenser to produce the refrigerated air.

   c. Vapor cycle systems make use of the scientific fa that a liquid can be vaporized by changing the pressure about it.

2. Select, from the following list, the type of refriger used in most vapor cycle air-conditioning systems. Circle the letter preceding your choice.

   a. Liquid ammonia.

   b. Carbon dioxide.

   c. Freon 12.

   d. Freon 22.

3. Match the following list of vapor cycle system components to their purposes. Place the letter preceding the component in the space provided adjacent to the purpose.

Component	Purpose
a. Compressor	____ Condenses the refrigerant to a liquid.
b. Oil separator	____ Causes a rapid expansion of the refrigerant to a gas.
c. Condenser assembly	____ Separates the oil from the refrigerant and returns it to the compressor.
d. Receiver	____ Acts as an expansion chamber for the refrigerant to absorb the heat surrounding the coils.
e. Filter dryer	____ Cleans and removes any water from the liquid refrigerant.
f. Expansion valve	____ Maintains the pressure differential required for the operation of the expansion valve.
g. Evaporator assembly	____ Stores surplus refrigerant and prevents surges in the refrigerant flow rate.

In the vapor cycle air-conditioning system, the compressor and the evaporator fan are each driven by a(n) _____ _____.

5. Complete the following statement. Circle the letter preceding your choice.

Temperature is controlled in the vapor cycle air-conditioning system by controlling the

a. speed of the evaporator fan.

b. speed of the compressor motor.

c. engine bleed air.

d. high-speed turbine.

your choice.

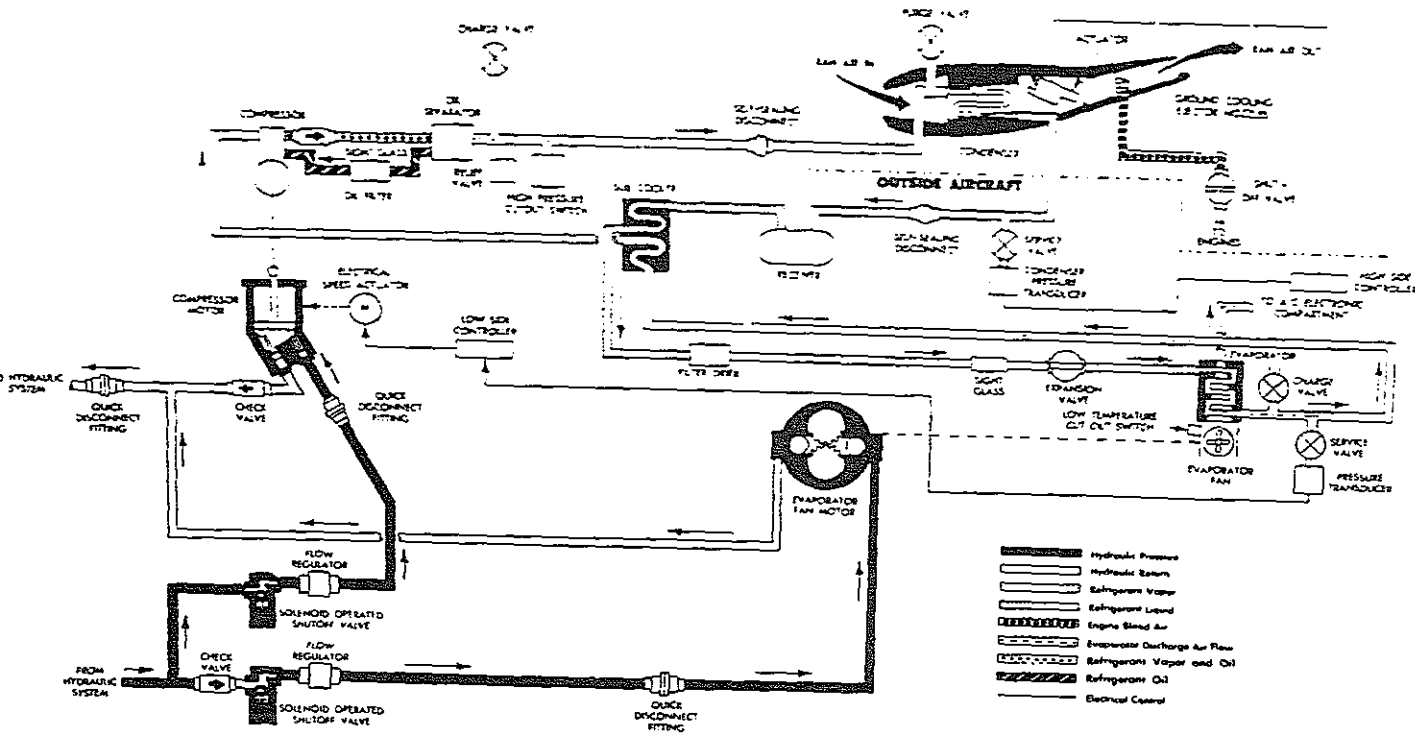
a. The heat of the space to be air conditioned is absorbed into the refrigerant vapor as it flows through the evaporator coils.

b. The heat of the space to be air conditioned is reflected by the use of light colors.

c. The heat of the space to be air conditioned is dissipated by forced air entering from an outside source.

7. Complete the following statements describing air induction during ground operation. Write in the spaces provided your selection from the words following each space.

During ground operation, sufficient airflow is induced through the _____ (evaporator/condenser) assembly by directing high-pressure bleed air, from the engines, through the ejector nozzles into the vapor cycle air scoop. This creates a _____ (low/high)-pressure area behind the _____ (evaporator/condenser) assembly.



Vapor cycle system flow schematic.

VAPOR CYCLE AIR-CONDITIONING SYSTEM COMPONENTS AND PURPOS

COMPRESSOR--Maintains the pressure differential required
the operation of the expansion valve.

CONDENSER--Condenses the refrigerant to a liquid.

EVAPORATOR ASSEMBLY--Acts as an expansion chamber for the
refrigerant changing to a vapor to absorb the heat
surrounding the coils.

FILTER DRYER--Cleans and removes any water from the liqui
refrigerant.

OIL SEPARATOR--Separates the oil from the refrigerant and
returns it to the compressor.

RECEIVER--Stores surplus refrigerant and prevents surges
the refrigerant flow rate.

EXPANSION VALVE--Causes a rapid expansion of the refriger
to a vapor.

THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends, the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us, our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

NAVAL LEADERSHIP

GENERAL ORDER
NO. 21

NAVY DEPARTMENT
WASHINGTON, D. C., 1 May 1963

LEADERSHIP IN THE UNITED STATES NAVY AND MARINE CORPS

Part I—Discussion

The United States Navy-Marine Corps records of victorious achievements on land, at sea, and in the air in peace and war have won for these services an honored position in our great nation. This heritage was passed on to us by our leaders, both officer and enlisted, whose outstanding examples of courage, integrity and devotion to duty are historically significant. They accomplished their missions successfully by high caliber leadership and personal example. The strength of our nation and of our services depends upon courageous, highly motivated and responsible individuals.

Part II—Objective

The objective of this general order is to achieve an ever-improving state of combat readiness by:

a. Emphasizing that successful leadership at all levels is based on personal example and moral responsibility.

b. Insuring that every man and woman are themselves examples of military ideals.

c. Requiring personal attention to and supervision of subordinates.

Part III—Action

1. The Chief of Naval Operations and the Commandant of the Marine Corps shall be directly responsible for maintaining optimum leadership standards. The Under Secretary of the Navy shall be responsible for the proper implementation of this order.

2. Fleet, Force, Type and Administrative commanders shall review each command's leadership posture as an integral part of military inspections and shall include their evaluation in inspection reports.

3. Every command and every major office and bureau of the Navy Department shall, on a continuing basis, review its leadership standards, each shall take effective measures to improve them and shall develop an awareness of the need for good leadership by providing programs for instruction in leadership principles and practices.

4. All persons in responsible positions, military and civilian, shall require that their subordinates discharge their duties in accordance with traditional concepts of Navy and Marine Corps standards, paying particular attention to:

a. Moral responsibility.
(Article 0702A, Navy Regulations. Paragraph 5390, Marine Corps Manual.)

b. Personal example of behavior and performance.
(Article 1210, Navy Regulations. Paragraph 5390, Marine Corps Manual.)

c. Established standards for personnel development.
(Article 0710, Navy Regulations. Paragraph 1500, Marine Corps Manual.)

d. Integration of principles and practices of leadership into everyday routine.
(Article 0702, Navy Regulations. Paragraph 5390, Marine Corps Manual.)

e. Effective organization and administration.
(Article 0701, Navy Regulations. Paragraph 3000, Marine Corps Manual.)

FRED KORTH
Secretary of the Navy

NAVPERS 15202